^{30}SI-ENRICHED PRESOLAR SIC IN ACFER 094.

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Ion imaging of ^{28}Si/^{30}Si ratios of SiC in the Acfer 094 meteorite identified a group of SiC grains with larger ^{30}Si enrichments than previously measured in presolar SiC in other meteorites. These grains, present at a level of ~0.2% of the "mainstream" SiC, are less abundant than the previously discovered SiC subgroups X (~1%), Y (~1%) and Z (2-3%) [1-4]. Grains of such low abundance will be practically impossible to find using conventional techniques. We report here the identification of three such grains in addition to the two presented earlier [5], as well as one new Z type SiC grain.

General surveys of presolar phases in Acfer 094 have shown that it contains the highest SiC concentration of any meteorite measured to date [5, 6]. Fifty-nine SiC grains were randomly chosen from our Acfer 094 separate for high-mass-resolution isotopic ratio analysis. The C and Si isotopic compositions of the majority of these grains are similar to those of the "mainstream" SiC in Murchison. One grain has isotopic compositions resembling the Z-type SiC [3, 4]. Low-mass-resolution ion imaging of ^{28}Si/^{30}Si ratios of ~6500 SiC found 71 X-type SiC grains consistent with our earlier study [5]. In addition, 14 grains with large enrichments in ^{30}Si (δ^{30}Si=300-1000‰) were also identified. Only 3 of them, however, were large enough to be re-measured at high mass resolution following the imaging analysis. The isotopic compositions of these grains along with the two from the earlier study and one graphite grain from the KFC1 fraction [7] are shown in the figure and listed in Table 1.

Z-type SiC grains were defined in previous studies by their Si isotopic compositions, with δ^{29}Si ranging from -30 to -140‰ and δ^{30}Si from -120 to 180‰ [3, 4]. Large variations in ^{12}C/^{13}C ratios, ranging from 8.2 to 182 were also reported. The five SiC grains from Acfer 094 have ^{30}Si excesses (δ^{30}Si=280-1200‰) beyond the range defined by the Z-type SiC and thus may represent one or more new subtypes of presolar SiC. The ^{12}C/^{13}C ratios in these grains varies from 9.5 to 93. Such grains have not been found by our ion imaging searches of Murchison KJG SiC, despite having analyzed a similar number of grains [8]. The difference is likely due to grain size; SiC in our Acfer 094 separate is typically <1μm whereas KJG SiC is nominally 2-4μm. We were able to measure the nitrogen isotopic compositions of Z grain SiC-23 and one ^{30}Si-rich grain (SiC-18-6). Both of them have ^{14}N enrichments with ^{14}N/^{15}N ratios of 2113 and 1822, respectively.

To understand the possible origin of these grains, we considered stellar objects capable of producing carbonaceous dust, including carbon stars (C-rich AGB stars), Wolf-Rayet stars, novae and type II supernovae (SN). With the current models of nucleosynthesis, no single source provides an obvious explanation of all the ^{30}Si-rich grains. Therefore, they may come from different stellar objects, and for this reason we choose not to classify these grains as members of a single, new sub-class of particles. However, the failure to find a single source may simply reflect the inadequacy of current stellar model calculations.

Carbon stars are considered to be the main contributor to presolar SiC [1, 2] and have been proposed as a possible source of Z-type SiC as well [3]. The isotopically-light N observed in grains SiC-23 and SiC-18-6 is consistent with an AGB-star origin for the Z grains and the new ^{30}Si-enriched grains. However, there are serious difficulties in explaining the totality of isotopic ratios of these grains in such a scenario. In particular, excess ^{30}Si dredged-up from the He-shell of a carbon star would be accompanied by excess ^{29}Si and large amounts of ^{12}C. As a result, grains with large ^{30}Si excesses from the third dredge-up would also be expected to have large ^{29}Si excesses and high ^{12}C/^{13}C ratios, unlike the compositions observed in the grains. Similar problems make a Wolf-Rayet star origin for the ^{30}Si-rich grains unlikely.

Novae and supernovae, on the other hand, plausibly account for some (but not all) of the grains. Specifically, a nova origin is possible for the two grains with the largest ^{30}Si enrichments, SiC-429-3 and the graphite grain KFC1a-551. Nova model calculations can reproduce, at least qualitatively, the C and Si isotopic compositions of these two grains [9, 10]. Because novae are also expected to produce very low $^{14}N/^{15}N$ and high $^{26}Al/^{27}Al$ ratios [9, 10], future isotopic measurements of N and/or Al (Mg) on the same or similar grains may help to confirm a nova origin. Similarly, the C and Si isotopic compositions of grain SiC-115-4 can be reproduced by partially mixing of C-rich and He/N zones of a 15 solar mass SN model [11].

Although we cannot find a single explanation for the isotopic properties of the ensemble of new grains, we remark that the grains exist and must someday be accommodated by theoretical stellar models.

Acknowledgments: We are grateful to E. Zinner and R. M. Walker for helpful discussions and we also would like to thank A. Bischoff for providing us with the original sample of Acfer 094.

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Table 1. Isotopic compositions of ^{30}Si-rich SiC grains

Grain Name	$^{12}C/^{13}C$	$^{14}N/^{15}N$	$\delta^{29}Si$	$\delta^{30}Si$
SIC-429-3	9.5±0.2		30±30	1227±44
SiC-18-5	76.9±7.6	1822±816	-157±45	282±55
SiC-86-2.	92.6±5.5		-104±24	372±30
SIC-23	55.3±0.3	2113±748	-90.3±3.6	-6.2±6.8
SiC-115-4	91.3±14		58±89	383±100
SiC-423-1	51±8.2		71±109	435±125
KFC1a-551	8.46±0.04	273±8	84±54	761±72